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PHYSICS AND THE FUTURE[1]

By Professor ARTHUR H. COMPTON
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As the conversation turned to the problems faced by our children, my table companion was confident of the future. "During their generation," she asserted, "life can not change as it has for us. Experience will once more be usable as a reliable guide."

If advances in our mode of life are to cease, will it not be the result of a stagnation of our knowledge and techniques? Let us see what present trends indicate with regard to the direction and extent of such future changes.

No better guide can be found to the future than a review of what has happened in the past. Let us accordingly examine the trend of physics through history. Taking the broad view that the science of physics is concerned with the applications as well as the principles of mechanics, heat, electricity, etc., it will be seen that such a review must consider also the growth of techniques and inventions, for these embody some of the most important scientific advances.

In his recent book, "Science and the New Humanism," George Sarton has emphasized the fact that science is almost the only aspect of human activity which shows a definite and continuous growth throughout history. Though advances in other fields have occurred, they have come for the most part as a result of development of techniques based on growing science.

We are accustomed to speak of the stone age, the bronze age, the iron age and the machine age. This sequence reviews in quick outline the growth of man with regard to the tools with which he has done his work. Each stage has been ushered in as some inquirer, more persistent or more fortunate than his

[1] Based on a paper read at Ottawa, June 29, before the American Association for the Advancement of Science.

predecessors and building on the foundation of their techniques, has learned some new facts regarding the properties of matter, the chemistry of metals or the laws of mechanics. Such mechanical inventions are not the only ones. Language and writing are among the most significant inventions of all, giving as they do means of communicating ideas, carrying on abstract thoughts and remembering happenings with definiteness. When the invention of printing, telegraphy, the telephone, radio and moving pictures are added, it becomes possible for people to share thoughts widely, to become quickly aware of what is happening to all mankind and to "remember" what has happened to men in the past. Thus the world becomes almost a conscious unit, very similar to a living organism. So even the non-mechanical inventions have found their most effective application through the aid of scientific developments.

Hand in hand with this development of invention has gone the increase in our knowledge of nature. The properties of matter had to be learned before tools could be fashioned. Knowledge of the forest to the hunter, of soil and weather, grains and animals to the farmer, these formed the science of primitive life. Then, as now, new discoveries, that wood could be set on fire, that a moving magnet would produce an electric current, made possible improved conditions of life. Likewise, improved techniques opened the door for new knowledge. Skilfully made lenses made possible a telescope, and Jupiter was found to be a miniature solar system. As high vacuum pumps were developed, x-rays were discovered, and with them came new knowledge of the structure of matter. "If I saw farther, 'twas because I stood on giant shoulders," is the statement ascribed to Isaac Newton, who clearly recognized the way in which one advance makes possible another.

The result has been an increase in the rate of growth of knowledge and of the control of nature which is one of the most striking phenomena of man's history. When old knowledge was passed on by tradition and new knowledge came by accident, progress was slow. The ancient thought he did things as they had always been done, for the changes during one's lifetime were imperceptible. With the modern era came a fundamentally new concept. Now we search for new knowledge, and use it for "enlarging the bounds of human empire." The knowledge of nature which from the beginning had been man's gradually but accidentally increasing heritage has now become the conscious objective of alert minds. Three centuries ago the hobby of a few amateurs, this enterprise of science has gradually become the most significant intellectual quest of man. As a result, changes for the better in our mode of living are the order of the day. Our life differs from that of two generations ago much more than did that from the life of two thousand years before.

To see the cumulative effect of this advancing knowledge, it is instructive to use the historian's device of compressing the time scale, shall we say by a million fold. We may then think of the first men as learning a year or two ago to use certain odd-shaped sticks and stones as tools and weapons. Sounds took on meaning, and speech appeared. Last week some one developed the art of skilfully shaping stones to meet his needs. Man became an artist, and by day before yesterday he had learned to use simplified pictures as symbolic writing. Yesterday the alphabet was introduced. Bronze was the metal that was most used. Yesterday afternoon the Greeks were developing their brilliant art and science. Last midnight Rome fell, hiding for several hours the values of civilized life. Galileo observed his falling bodies at 8:15 this morning. By ten o'clock the first practical steam engine was being built. At eleven the laws of electromagnetism were developed, which by eleven thirty had given us the telegraph, electric power, the telephone and incandescent electric light. At twenty minutes to twelve, x-rays were discovered, followed quickly by radium and wireless telegraphy. Only fifteen minutes ago the automobile came into general use. Air mail has been carried for hardly five minutes. Not until the last minute have world-wide programs broadcast by short wave radio become popular. Now at noon we find mankind in a wholly new sense unified by science.

Science has thus become the basis of civilization, and is the primary factor in promoting its growth. During recent years it has been the science of physics whose activity seems to have been most significant in this regard. Just as earlier society was based upon agriculture and local trade, so modern communities are built upon the scientific foundation which makes possible rapid transportation and communication, the preservation and distribution of food and adequate sanitation. With only primitive knowledge of metallurgy, mechanics, electricity, chemistry and hygiene, our cities could not exist; and with them gone, country life also could have only a primitive form. It is on this basis that the president of the Massachusetts Institute of Technology has made the claim that in the last fifty years physics has exerted a more profound influence in changing all aspects of life than has been exerted in a comparable period by any other agency. The development of previous ages has grown to a mighty crescendo, within which we are living.

The growth of this scientific activity may be thought of as an aspect of social evolution. It supplies the knowledge which enables men to use the materials of nature for supplying their wants. The

process involves specialization of function, which enables certain men to acquire extraordinary knowledge and skill in special fields. One important aspect of this process is the recent establishment of research laboratories. We have noted how the growth of knowledge, which had been mostly of an accidental nature, became with the modern era of science a primary objective of professional research men. Astronomical observatories and industrial research laboratories have pointed the way. In no field have these investigators proved their value more conclusively than in physics and the allied techniques. We may thus state with assurance that during the coming generation research in physics will continue with more and better trained investigators, with better organization and equipment, than during the past generation. We should accordingly expect an increasingly rapid growth of physical science, except in so far as the law of diminishing returns may make research effort less productive than during the past generation.

Present Trends in Physics

By surveying one after the other the various fields of physics, we may gain some idea of the new advances that may be expected. In its fundamentals, physics is concerned with the relations between time, space and matter. During the past thirty years, remarkable advance has been made with regard to our understanding of our own position in space and time.

Two generations ago we had just become aware that the earth and life on it had existed for a very long time as measured in terms of the human life span. Since the development of radioactive methods of time measurement, we have been able to date the formation of rocks with precision and to assign a reliable though rough estimate of some billions of years to the age of the earth. In fact, the age of the universe itself, as shown by the stars and galaxies studied by powerful telescopes, has been put under searching scrutiny. Theoretical estimates have varied from an eternal universe to one whose duration has hardly exceeded that of the earth. There is little doubt but that within the next thirty years our information on this point will have been made much more reliable and precise. That is, we may hope to find out when the world was made.

In tracing man's origin to the Miocene age of more than a million years ago, and the origins of civilization to some five thousand years B.C., the geologists and archeologists have made important contributions to the physicist's problem of measuring time and enabling man to understand his own position with relation to the time scale. It thus becomes clear that an adequate consideration of "science and the future" must include a consideration of a future extending not only into thousands but possibly into millions of years.

One of the major technical achievements of the past century has been the great reduction of time required to communicate ideas and to accomplish desired ends. Fast mail, the telegraph, telephone and radio—these have enabled people for the first time to act and think in unison. At last it is possible for men the world over to act as a social unit if they so desire.

Not the least significant in this direction is our increasingly accurate control of time. Galileo's invention of the pendulum clock was an important step in this direction. The recent wide-spread introduction of electric clocks using accurately synchronized alternating current and of precise time signals broadcast by radio at frequent intervals have made practicable the planning of our daily lives according to more definite schedules. Precision electric and pendulum clocks are now timing the earth's rotation to study its irregularities. In ultra-short wave radio, time intervals are measurable in trillionths of a second. In atomic physics we are concerned with processes whose duration varies from more than a billion years down to less than a billion trillionth of a second.

In a similar way we may trace man's increasing understanding and control of space. Perhaps nothing has had more influence on man's attitude toward nature than the gradual unfolding of the immensity of the world. Starting with Galileo's discovery of the moons of Jupiter, which gave the first convincing evidence of the truth of the theory that the earth revolves about the sun, our known universe has now been extended to hundreds of millions of light years. Because of a change in the energy of the light from these far spaces it would seem that our knowledge will be forever limited to distances not much greater than are now known. In this sense at least we may consider our universe as finite, and in spite of telescopes of increasing size we need not expect the future to open to us much vaster vistas. Here, on the side of the very large, is thus placed a natural limit to future scientific advance.

Similarly in the field of the very small, though size alone gives no insuperable limit to our knowledge, both experiment and theory agree in indicating that the measurement of motion of objects must become less precise as their size becomes smaller. This means that we do not hope to be able to predict exactly what will happen to particular atoms. Statistical predictions of the average of many trials is all that can be hoped for. It is possible that this limitation may be of importance in the application of physics to certain problems concerned with the action of living organisms.

These examples suggest that there are fields of knowledge which may be forever beyond our ken. It would not be surprising to find other similar limits

presenting themselves, as researches in other directions become more far-reaching. Thus there has been, in the last thirty years, no significant advance in the precision of ordinary distance measurement since Michelson's calibration of the standard meter in terms of light waves to one part in several million.

It is unnecessary to consider the manner in which rapid transportation is giving us increasing control of distance. Nor need we emphasize the increasingly accurate construction and measurement of manufactured articles. These important trends have shown such value that there is no doubt of their continuation and extension.

We may properly include as a major trend in physics the increasing control of large and small masses in manufacturing operations. The building of gigantic ships and bridges with reliably calculated strengths represents one extreme. Milady's miniature watch or the biologist's micromanipulator for dissecting individual cells is the other. Though these trends will doubtless continue, it is not to be expected that along this line the next century will show an advance comparable with that of the last. When objects are of dimensions of the order of a thousand feet, gravitational forces become of such importance as compared with cohesive forces that further increase in size becomes rapidly more difficult. By using steel of the highest tensile strength, such spans as the Golden Gate bridge become possible. Light alloys should extend the limiting size somewhat; but nature has set a limit to the distance between supports of objects, which at best is roughly five or ten miles, and for most forms of objects is much less.

Similarly, we are already working with things so small that their molecular motions are appreciable. Molecular bombardment is now a limiting factor in the precision of electrometers and galvanometers, so that further decrease in size is of little value. For scientific work, including living cells, metallurgy, atomic studies, etc., there is, however, much to be gained by further emphasis on observing and handling microscopic masses.

Corresponding to the extension of our knowledge of distances, there is a similar extension in our knowledge of masses. It was almost two centuries ago that Cavendish weighed the earth and thus made possible the measurement of the masses of the sun and planets. Only within the last generation has it become possible to estimate reliably the amount of matter in our galaxy. We can even begin to guess with some confidence the mass of the knowable universe. Similarly since 1900 precision methods have been developed for weighing molecules, atoms and sub-atomic particles, even including that most elusive of objects, a single ray of light. Having thus weighed the largest and smallest of things, further extension of this art must be in the direction of refinement and simplicity of measurement.

These developments in our knowledge and control of time, space and matter constitute the growth of the fundamentals of physics. Only a brief mention can be made of modern trends in the more detailed aspects of the science.

Both physics and chemistry are concerned with developing materials with desirable properties. The recent great advances in this direction will doubtless be discussed by Professor Urey. The dynamics of moving bodies, which from the time of Galileo to the present century had been primarily of academic interest, has with the use of the automobile become an essential part of everyday knowledge. With the development of aerodynamics, hydrodynamics has likewise received new impetus.

Perhaps the most significant mechanical advance of the last century, however, was the development of sources of power, steam and gas engines and water turbines. The efficiency of conversion of potential and chemical energy into useful work by these engines has increased from an original few per cent. to a value so high that though further advances are possible they can not greatly alter the power situation. We are favored for the time being with plentiful supplies of fuel in coal and oil. Within a century petroleum will have to be extensively supplemented by artificial liquid fuel, a procedure already followed in Europe. Within a thousand years the more readily available coal will be approaching exhaustion. New sources of power will thus gradually become of importance. Sources now available include agricultural products, such as wood and alcohol, water power, wind power and direct solar heat. Of these, perhaps that of agricultural products has the greatest promise of becoming a major power source. It is apparent, however, that unless fundamentally new developments occur, future generations will not be as favored as we are with regard to available power.

One of the major problems of the physics of the future is thus to investigate all sources of energy which show promise of being important. A hopeful lead is the inexhaustible flow of energy from the sun and stars in the form of radiant heat. Geological records indicate that for a billion years the sun has poured heat upon the earth at about the same rate as it now comes to us. Chemical energy, such as coal burning in oxygen, could not supply this power for more than a thousand years before the sun would cool. Within the last twenty years several theories of stellar heat have been put forward, the most promising of them based upon atomic nuclear reactions similar to radioactivity. In the laboratory, it has been found that such nuclear reactions can be produced and are

capable of supplying heat in the necessary amounts. We do not yet know, however, how these nuclear reactions are made to occur efficiently on the sun, nor have we any assurance that they can be brought about on earth in such a way as to act as a source of energy.

Our situation in this regard is similar to that of the primitive man who felt the pleasant warmth of a forest fire, but had not learned how to keep the fire alight, much less how to kindle it. We know the desired energy is present on the earth. We hope to learn how to make it available to man.

There is thus no reason to be pessimistic with regard to power supply. It may require a decade, a century or a thousand years, but there appears no reason to fear man's inability to find an adequate new supply before the failure of power sources now developed limits the advance of society.

It is evident that we have only begun to appreciate the many uses of power. Heat, artificial light and running water have become almost universal in this country. Refrigeration, including air conditioning, is rapidly expanding its usefulness. Electric power and heat in the home, power for transportation and for industry—here is a trend that is upward, with no limit now in sight. The trend in the electrical distribution of power seems to be toward placing power plants near sources of fuel or water power, and transmitting the energy by high tension. Here physical problems of electrical insulation and electrical resonance are involved. Great improvements in high voltage insulation and very possibly use of direct current will make possible much farther transmission at much higher voltages.

The efficiency of electrical motors, generators, transformers and heaters is already so nearly perfect that further improvements in this direction are unimportant. There is considerable room, however, for improvement in the efficiency of electric lighting. Though notable advances have been made within the last generation, it remains theoretically possible to produce more than ten times as much white light for a given expenditure of power than is now given in ordinary house lighting. The fluorescent lighting now being introduced marks another important step toward high efficiency lighting; but more remains to be accomplished.

Special mention should be made of the physicist's studies of low temperatures, using liquid helium at fractions of a degree above absolute zero. Here the ordinary physical properties of elasticity, heat capacity and electrical conductivity are greatly altered. Recent developments have made this extreme cold accessible without great difficulty. We have not yet found important industrial uses for such low temperatures, but there is good reason to anticipate significant scientific advances from studies in this field.

It would appear that optical instruments have approached close to the limit of their technical development. The wave structure of light prohibits appreciably higher optical resolution than is attained by present instruments. Rapid development is, however, in progress in the understanding and use of rays of other wave-lengths. Within the past fifteen years the complete spectrum of electromagnetic waves, from the longest wireless waves, through heat rays to light, and on from ultraviolet to x-rays, gamma rays and cosmic rays, has been explored. In the short-wave regions of ultraviolet and x-rays, and in the long-wave regions of infra-red and radio waves, efficient radiators are available, and the properties and possibilities of the rays are well understood. There remain, however, intermediate regions, especially that of waves from a millimeter to a centimeter in length, which hold significant scientific and practical possibilities, which have not been developed.

Closely associated is the question of communication. Every stage of this advance has followed upon some fundamental discovery in physics. The work of Oersted, Ampere and Henry on the magnetic effect of the electric current led directly to the telegraph. The electric waves of Maxwell and Herz made possible Marconi's wireless. Radio broadcasting had to await the electron tube of Richardson and de Forest. The photoelectric cell is essential to television. There remains great room for advance in this field, using the physical laws and techniques now understood. One can not predict what new principles may appear which will bring about further epochal changes.

There are many professional physicists who are not at all concerned with the practical applications, but solely with the fundamental principles of their science. The understanding of the physical world is their objective. Within the last half century they have found the atoms postulated by Democritus two thousand years ago and have learned much regarding their structure and properties. Sub-atomic particles have also been found and investigated, electrons, positrons, neutrons, photons, barytrons and neutrinos, the building blocks of which the world is made. Some of these particles are known only as visitors, coming to us as cosmic rays from remote space. Their masses and electrical charges are known. When these particles approach each other at very short distances, new kinds of forces have been found, which overpower the ordinary electrical and gravitational forces.

Similarly, the physicist looks outward. He finds with Einstein that for rapidly moving planets a slight modification of Newton's law of gravitation is necessary. At distances greater than the diameter of our galaxy there apparently appears a repulsive force which becomes greater than gravity and makes galaxies fly apart.

He suspects his laws of electrodynamics and of the conservation of energy, and subjects them to more searching tests. For this work no laboratory particle has sufficient energy. He must use a cosmic ray with a thousand times the energy that he can develop by electrical methods.

The Growing Influence of Physical Discoveries

If such a physicist can appreciate more adequately his place in the world and why things are as they are, he has a sufficient reward for his effort. This knowledge forms an essential part of man's cultural heritage. Yet its importance is also great in shaping men's lives. Its significance in this regard can perhaps be best indicated by citing examples. Consider the discovery of electromagnetic induction by Faraday and the discovery of x-rays by Roentgen.

Faraday's discovery was considered a century ago as a purely scientific curiosity. It was recognized that here was a means of producing an electric current, and laboratory generators were made. But why should the public be interested in electric current? It was fifty years later, when Edison showed the value of electricity in lighting houses, that the importance of Faraday's discovery began to be evident. With regard to the effect it has had upon the lives of men, it is, I believe, demonstrable that the discovery of electromagnetic induction was the most important event of the nineteenth century. Empires would fall apart, society would become disorganized, if the electrical machines based upon Faraday's discovery were put out of commission.

Roentgen's discovery was made within the lifetime of most of those listening to this address. What could be of more purely academic interest than extending the spectrum of electromagnetic radiation to a thousand-fold shorter wave-length? That was Roentgen's achievement. I have tried to think of the most important event that has happened in my lifetime. Perhaps it was the world war. Let us then compare the consequences of Roentgen's quiet announcement of x-rays in 1895 with those of the dramatic events which in 1914 plunged the world into war. Let us speak in terms of human values, life and death, attitudes, means of living, the organization of society.

First consider death. Such data are hard to find. The war lords do not want them advertised. I have, however, recently looked up the figures. In the world war there were about 8½ million soldiers killed in all the armies, one fourth of the able-bodied men now living in the United States and Canada—a tremendous slaughter. Yet of the 450 million people then living in the countries at war, some 50 million will have died of cancer. The lives of some three million others will have been saved from cancer by the use of x-rays and the radium which was discovered as a result of x-rays. If you add to these the considerably greater number whose lives have been saved by the x-ray diagnosis of tuberculosis, a broken bone or an infected tooth, it becomes evident that even in the warring countries x-rays will have saved as many lives as were taken in battle.

"But," I hear you saying, "what of the vast political and economic disturbance caused by the war?" X-rays have also had their great economic and political effects, not so dramatic, but perhaps even more far-reaching. What does it mean to the economic and political life of the United States to be integrated by radio? For one thing it means that we are a unit of governable size, with no apparent tendency toward disintegration. It means nation-wide markets for centrally produced and advertised goods. Yet without x-rays, no radio. For the radio is the child of the electron, and the electron owes its recognition to the ionization of air by x-rays. Similarly, were it not for x-rays we should not now have sound movies or long-distance telephony or radio beacons to guide air mail or a multitude of other devices that rely upon electrons for their operation.

But the real significance of such a discovery as x-rays is much deeper. Physics lay stagnant. "The future lies in the next decimal place," was the current phrase of the day. With it inactive, other fields of science were also developing but slowly. For twenty years the idea of ions had been making poor headway in chemistry and physics. The announcement of x-rays kindled a tinder box. Never perhaps has history shown such an outburst of scientific activity. Thousands of investigators set themselves to study the newly opened possibilities. Within a few months came the announcement that x-rays dissociate air and other gases into charged ions, and chemistry had the impulse that was needed to start it on its phenomenal modern growth. Another few months, and radioactivity was discovered, leading to radium and all its consequences. Another year or two and electrons became known. The atomic theory was now on a firm basis, but the atom itself was found to have a structure. Not an important field of science but was stimulated by these developments. The geologist had placed in his hands a radioactive clock for measuring the ages of his rocks. The biologist was given an artificial method of producing mutations, changing species at will. The psychologist received electron tubes for measuring nerve currents. The scientific world was set aflame. While many advances would have occurred without Roentgen's discovery, its appearance greatly stimulated these advances. One may say that the modern scientific era was ushered in by x-rays.

If science has come to have a determining place in our economic, social and intellectual life, it is because of such discoveries as this. Strictly speaking, one such achievement should not thus be singled out as if it alone had caused these transformations; for the whole body of science is closely interrelated. Roentgen's discovery is rather to be compared with a declaration of war which initiates a whole series of world-shaking events. On this basis, as seen after forty-three years, the discovery of x-rays is thus quite comparable with the starting of the world war.

But here is a vast difference. The scars of the great war are rapidly healing. New alliances are being formed. Future wars are being planned and old ones forgotten. Science's achievements, on the contrary, are of growing significance. Recent discoveries have not yet shown their human worth. Had we used Faraday's discovery of electromagnetic induction instead of the much later one of Roentgen, our comparison with the world war would have been too one-sided. Electrical machinery is vital to the world's existence. Industrially, politically or socially, it is now far more significant than the result of any past war. We have seen the growing value of the discovery of x-rays. A century from now, when the world war means no more than the pages of history describing Napoleon's conquests mean to us now, x-rays and the developments consequent upon it will have become of a significance comparable with that of electricity to-day. Physics and the future! All history demonstrates the growing value of scientific discoveries. Fire, the wheel, handling of iron and steel, the laws of motion and electricity, never have they meant as much to man as to-day. By the same token we can be confident of the permanent value of the scientific achievements of our own age.

In the past there have been alternating periods of rapid scientific advance and relative stagnation. There are now definite signs of a decline of physics research in central Europe; but the increasing interest in both fundamental and applied physics in other parts of the world indicates that this decline is a local rather than a world trend. The Orient has joined the Occident in physics research. India contributes to our knowledge of scattered light and of stellar atmospheres; China interprets atoms by scattered x-rays; Japan develops iron with new magnetic properties. British research is carried on throughout the empire. Mexico joins effectively in the study of cosmic rays. With physics research now truly world-wide, the future advances can hardly be greatly affected by local political disorders. On the other hand, we may continue to expect periods of relative stagnation following the solution of problems that occupy the attention of leaders of the science. This was the situation in physics toward the close of the nineteenth century after classical mechanics and electrodynamics had been developed, and again in 1930 for a brief period, following the development of quantum mechanics. Very probably similar quiescent stages will follow the solution of the major problems of nuclear physics and cosmic rays. As before, however, these quiescent stages should be only temporary, for many physics problems remain to be solved and the rewards for their solution are great.

Physics and a Stabilized Society

The growth of physics is thus intimately bound to the future of civilization. Advances in science and techniques go hand in hand, and both become easier in a well-organized society where specialists can develop highly specialized skills. It is thus impossible to conclude an adequate statement about physics and the future without some consideration of the mutual relation between physics and the organization of society.

It has become clear to all who have their eyes open that the great power given to man by his new knowledge of the world may be used either to his good or to his harm. Without cooperation, we have seen that this knowledge can not be made fully effective. If men divide into antagonistic groups it may become terribly destructive. When it becomes sufficiently evident that the welfare of the more powerful communities depends upon cooperation rather than upon strife with others, we may expect such cooperation to be not far distant. The growth of physics, through its great advances in communication, its highly specialized and interdependent industries, and the great power given to industrially organized communities, is rapidly bringing about just this condition, where strife endangers every one and cooperation gives rich rewards to all. Thus, not only does physics need well-organized civilization for its own development, but it is in itself a powerful factor in stabilizing such a cooperative society.

OBITUARY

FRANK BURSLEY TAYLOR

Frank Bursley Taylor was born in Fort Wayne, Ind., on November 23, 1860, the only child of Judge Robert S. and Fannie Wright Taylor. His father was nationally known as a master of law in cases involving electrical sciences and a man of superior talent and broad interests. Taylor was graduated from the Fort Wayne High School in 1881, but because of poor health

he deferred entering Harvard University until 1882. He there took an elective course seeking no degree, and gave especial attention to geology and astronomy for two years, being much interested in their lines of contact.

In order to gain more vigor, Taylor then traveled with a physician as companion quite widely in the upper Great Lakes region, giving attention to high shore lines and former lake outlets. His family spent their summers on Mackinac Island, and the first contribution he made to geologic literature was a paper on "The Highest Old Shore Line of Mackinac Island," published in the *American Journal of Science* in April, 1892. This was followed within the next two years by several papers in the *American Geologist,* covering results of his reconnaissance work in the Superior, Michigan and Huron basins. Having traversed what is now known as the Nipissing Outlet from Georgian Bay past North Bay to the Ottawa River, he interpreted it as a strait connecting Georgian Bay with the Gulf of St. Lawrence and published a paper on "The Ancient Strait at Nipissing" in the *Bulletin* of the Geological Society of America, Volume 5, 1893. Between 1895 and 1897 he extended studies southward in the Michigan and Huron basins and gave attention to moraines as well as shore lines.

Up to 1900 Taylor had conducted investigations at private expense. He then became connected with the U. S. Geological Survey, and for several seasons did detailed mapping of moraines and shore lines as an associate with the writer in Michigan and neighboring parts of Indiana and Ohio, the results of which are presented in Monograph 53, U. S. Geological Survey, published under our joint authorship in 1915.

In 1908 and 1909 Taylor worked under the auspices of the Geological Survey of Canada in the southern part of Ontario, making a hurried reconnaissance of a wide area, and giving attention to moraines as well as shore lines. The results appear in the *Transactions* of the Canadian Institute for 1913 under the title "The Moraine Systems of Southwestern Ontario." He later made a special study of Niagara Falls, on which is based "The Niagara Folio,"[1] published in 1913. He also spent one or two seasons under the auspices of the U. S. Geological Survey in field work in Massachusetts and Connecticut in an attempt to work out the method of recession of the Wisconsin icesheet.

About 90 titles of papers and reports by Taylor are listed in the Bibliography of North American Geology between the years 1892 and 1934. Several papers deal with subjects on the border line of astronomy and geology. They discuss the origin and growth of satellites and planetary systems; tidal forces and horizontal sliding of continental crust sheets; the preeminence of Asia in Tertiary diastrophism, etc. Because of these papers, Daly and others have coupled Taylor's name with Alfred Wegener's and made references to "The Taylor-Wegener Hypothesis" as if their views were similar or harmonious. This was a source of regret by Taylor, as he did not subscribe to the Wegener hypothesis of a drifting of continents by flotation.

Aside from his scientific work, Taylor was much interested in artistic and literary subjects, and was a member of the American Academy of Arts and Sciences. He served as president of a Fort Wayne art school, of the Allen County, Indiana, Historical Society and of the Fortnightly Club. He was thus a guiding spirit of the community.

He married Minetta Ketchum, of Mackinac Island, in April, 1899, who survives him. Mrs. Taylor has been a constant participant in all his work. In much of the field work it was she who drove the team, and later the auto, giving him freedom for observation and notes. Thus with her help his delicate health ceased to be much of a handicap, and he was able to cover a large field in a creditable manner. His death occurred on June 12, 1938, after an attack of coronary thrombosis on June 10.

FRANK LEVERETT

[1] Folio No. 190, U. S. Geological Survey.

RECENT DEATHS

DR. CHAS. H. HERTY, research chemist in charge of the Pulp and Paper Laboratory of the Industrial Committee of Savannah, Georgia, died on July 27 in his seventy-first year.

DR. TRUMAN MICHELSON, since 1910 ethnologist of the Bureau of American Ethnology of the Smithsonian Institution, died on July 26 at the age of fifty-eight years.

DR. G. M. JOHNSTONE, MacKay director of research at the Stamford, Conn., laboratories of the American Cyanamid Company, died on July 29 at the age of fifty-five years.

MRS. YNES MEXIA, of Berkeley, Calif., botanical collector, died on July 12 at the age of fifty-eight years.

FRANK M. BAUER, president of Pfaltz and Bauer, Inc., dealers in chemical apparatus, New York City, died on July 20.

Nature reports the death of Dr. A. E. H. Tutton, an authority on chemical and physical crystallography, formerly H. M. inspector of schools, Technological Branch, British Board of Education, on July 14 at the age of seventy-three years; of Sir Colin Mackenzie, formerly director of the Australian Institute of Anatomy, aged sixty-one years, and of H. N. Thompson, lately director of forests, Nigeria, on July 9.

SCIENTIFIC EVENTS

THE ALBERT FARWELL BEMIS FOUNDATION

Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, has announced the establishment of the Albert Farwell Bemis Foundation, dedicated to the advancement of housing for the benefit of the public and of the building industry. The purpose of the foundation will be to search for and disseminate knowledge pertaining to adequate, economical and abundant housing.

The establishment of the foundation has been made possible by a grant from the Albert Farwell Bemis Charity Trust, the trustees of which are Farwell G., Alan C. and Judson Bemis, sons of the late Albert Farwell Bemis, of Boston. The new foundation is a memorial to their father, who died in 1936.

The foundation, which will be a separate division of the institute, perpetuates the life-long interest of Mr. Bemis, who believed, after many years of pioneering studies, that better and more economical housing could be achieved only through improvements in the technology of building.

The foundation will be directed by John E. Burchard, of Winchester, who for several years has been vice-president of the Bemis Industries, Inc., where he was closely associated with the late Mr. Bemis in research on housing and the utilization of housing materials. Mr. Burchard will begin his work as director of the foundation in September.

The foundation will cooperate with various departments of the institute, especially the departments of architecture and civil engineering, and the division of industrial cooperation, the three departments whose work most closely approaches that of the foundation.

The major policies of the foundation will be determined by the president of the Massachusetts Institute of Technology with the counsel of an advisory committee, the members of which will be men prominent in the architectural and building professions.

The general program will include:

Coordination of the available knowledge on materials, construction methods and the economics of shelter.

Stimulation and planning of research in various phases of the building industry.

Dissemination of information on its various activities for the greatest benefit of the public and the building industry.

Cooperation with all departments of the institute in making available the latest material on housing for undergraduate and graduate instruction in the institute.

As a central organization for the study of housing, the foundation is expected to play an important part indicating and preparing for research fundamental problems the solution of which will contribute notably to the technological advancement of building. Other problems involving the economics of housing are the transportation and distribution of building materials, studies of the effect of mass production in those portions of the building industry where this technique has been applied, analysis of the cost of existing houses in terms from which conclusions may be drawn; land development studies; studies of building costs in terms of maintenance. The entire field of building materials may also be of interest to the foundation, particularly the behavior of building materials in combination as opposed to their behavior individually. The foundation plans to publish the results of its activities at such times and in such form as will be of the greatest assistance to the public and to industry.

THE PROPOSED POLISH BALLOON FLIGHT INTO THE STRATOSPHERE

The National Geographic Society, after a conference with members of the Polish Embassy staff, has announced that the next manned-balloon flight into the stratosphere will be made from Poland in September, under the auspices of the Polish army. The pilot will be Captain Zbigniew Burzynski, who has returned to Poland after a visit to the United States, during which he consulted with Major Albert W. Stevens, who commanded the stratosphere flight of the National Geographic Society and the U. S. Army Air Corps in 1935, and with specialists of the National Bureau of Standards, who designed some of the instruments used in the ascent.

The balloon, which is almost completed, will be considerably larger than the *Explorer II* of the Geographic-Army flight, and will be made of rubberized silk, which was both grown and processed in Poland. Its volume will be more than 4,800,000 cubic feet as against 3,700,000 cubic feet for *Explorer II;* the height at take-off time, 459 feet as against 315 feet, and the greatest diameter 209 feet as against 192 feet. In spite of this greater size, the bag will weigh only 3,300 pounds instead of the 6,350 pounds of *Explorer II,* owing to the lesser weight per square yard of the silk fabric. The spherical gondola to be used will be made of aluminum and steel.

Balloon and gondola together, ready for flight, will weigh less than half as much as *Explorer II,* so that it should reach a much greater height, probably 81,000 feet (15 1/3 miles) above sea level. *Explorer II* established the present world altitude record of 72,395 feet (approximately 13¾ miles), in an ascent from the Black Hills, near Rapid City, S. D., on November 11, 1935.

Captain Burzynski will be accompanied by Captain F. R. Hynek, also of the Polish Army, and Dr. Yodko Narkiewicz, Alpinist and explorer. In 1935 they established a record by remaining in the air fifty-seven hours and forty-five minutes, while flying from Warsaw into Russia. The flight will be made from a valley in the Tatry Mountains near Zakopane, in southwestern Poland near the Czechoslovakia border. Studies to be made will include cosmic radiation, pressure and temperature. Among the instruments to be used will be several loaned by the National Geographic Society which were used in the flight of *Explorer II* in 1935. Funds amounting to nearly $200,000 were raised by popular subscription.

Since the flight of *Explorer II* three attempts have been made to penetrate the stratosphere. On March 9, 1936, two Russians, ascending from Moscow, reached an altitude of 10,000 meters (about 32,808 feet) in a balloon of only 77,700 cubic feet capacity. On May 25, 1937, at Brussels, Professor Auguste Piccard's balloon caught fire from a gas burner used to heat air for lifting the balloon, as the ground crew were attaching the basket for the ascent of Piccard and Max Cosyns. On July 18, 1937, Professor Jean Piccard took off at Rochester, Minnesota, in a gondola lifted by a group of small balloons and, six hours later, crashed into the treetops near Lansing, Iowa. He attained a height of 11,000 feet.

LECTURES GIVEN BEFORE THE DEPARTMENT OF PHYSICS OF CORNELL UNIVERSITY

DURING the academic year 1937–38 reports by nonresident speakers were presented at meetings of the faculty and graduate students in physics at Cornell University as follows:

November 1, "Molecular Beam Methods of Measuring Nuclear Moments," Professor I. I. Rabi, Columbia University.

November 22, "The Diffraction of Fast Electrons by Gas Molecules," Professor Linus Pauling, California Institute of Technology.

December 16 and 17, "The Dielectric Constant of Liquids and Solids and Ferromagnetic Anisotropy," Professor J. H. Van Vleck, Harvard University.

January 17, "Stresses and Constitutional Changes in Glass During Cooling," Dr. H. R. Lillie, Corning Glass Works.

February 14, "Some Vacuum Tube Research Problems," B. J. Thompson, R. C. A. Research Laboratory.

March 21, "Some Problems of Galactic Dynamics," Professor K. Lundmark, University of Lund.

March 24, "Transmutations of Heavy Nuclei," Professor V. Weisskopf, University of Rochester.

April 18, "Recent Work in the Cavendish Laboratory," Dr. M. Goldhaber, University of Cambridge.

May 9, "Some Physical Phenomena at the Temperature of Liquid Helium," Professor E. F. Burton, University of Toronto.

May 23, "Crystal Fluorescence," Dr. Frederick Seitz, General Electric Research Laboratory.

ORGANIZATION OF THE NATIONAL ASSOCIATION OF BIOLOGY TEACHERS

THE organization meeting of the National Association of Biology Teachers was held in New York City on July 1.

Fifteen delegates, representing approximately fifteen hundred pledged members in thirty-five states, adopted a constitution, elected officers and established a journal which will be known as *The American Biology Teacher*.

The purpose of the association as stated in the constitution is to organize biology teachers on a national basis by local units in order to spread vital and useful biological knowledge to the general public; to encourage scientific thinking and the scientific method, and through the journal to make available to biology teachers information concerning the selection, organization and presentation of biological materials.

The association is sponsored by the committee on biological science teaching of the Union of American Biological Societies, of which Dr. Oscar Riddle, of Cold Spring Harbor, N. Y., is chairman and Dr. D. F. Miller, of the Ohio State University, is field representative.

The officers of the association are as follows:

President, M. C. Lichtenwalter, Chicago, Ill.
President-elect, Malcolm D. Campbell, Boston, Mass.
First vice-president, George W. Jeffers, Farmville, Va.
Second vice-president, Lucy Orenstein, New York, N. Y.
Secretary-treasurer, P. K. Houdek, Robinson, Ill.
Acting editor-in-chief, I. A. Herskowitz, New York, N. Y.
Managing editor, J. S. Mitchell, Lexington, Ky.

Inquiries concerning membership and subscriptions to the journal should be sent to the secretary-treasurer, P. K. Houdek, Township High School, Robinson, Ill.

THE AMERICAN MEDICAL ASSOCIATION AND THE GROUP HEALTH ASSOCIATION, INC.

ACCORDING to reports in the daily press, the Department of Justice on July 31 charged the American Medical Association and its affiliate, the District of Columbia Medical Society, with violation of the antitrust laws in an attempt to prevent the functioning of the Group Health Association, Inc. Thurman W. Arnold, assistant attorney general, has announced that evidence obtained in an investigation would be presented to a grand jury. The charges against the association are:

1. Threatened expulsion from the District Medical Society of doctors who accept employment with the group.

2. Threatened expulsion from the Medical Society of

doctors who take part in medical consultations with doctors of the group.

3. The expulsion from Washington hospitals of the Group Health Association staff doctors.

In the opinion given by Mr. Arnold he says:

The department believes that the anti-trust laws make it illegal for medical societies or individual practitioners to obtain or retain for themselves a monopoly of the communities' medical services, so long as adequate standards are maintained in the treatment of patients among those doctors who are willing to serve cooperative or other groups.

No combination or conspiracy can be allowed to limit a doctor's freedom to arrange his practice as he chooses so long as, by therapeutic standards, his methods are approved and do not violate the law.

Organized medicine should not be allowed to extend its necessary and proper control over standards having to do with the science and art of medicine, to include control over methods of payment for services involving economic freedom and the welfare of consumers and the legal rights of individual doctors.

THE MARINE BIOLOGICAL LABORATORY AT WOODS HOLE

This year marks the fiftieth anniversary of the founding of the Marine Biological Laboratory at Woods Hole, Mass. In the summer of 1888 the first building was opened for the use of seven investigators (all save one were beginners), and eight students. Professor C. O. Whitman, of Chicago, was the director. The laboratory was scantily furnished with glassware and other necessities; living material was collected in a rowboat; the library consisted of a few volumes on a shelf, which also carried the supply of chemicals. During the half century which has followed, the institution has grown until the attendance is more than 500. To the original building, still used for investigation and research, have been added other wooden buildings, and a large brick laboratory containing a remarkably complete library, research rooms equipped with running fresh and salt water, well-stocked chemical and apparatus rooms, a very efficient x-ray installation and a large auditorium. The supply department now has power boats, a fish trap and other equipment needed for its very important task. In the past fifty years the institution has grown from a very modest beginning to a position of world-wide influence in biology.

At an informal meeting to celebrate the semicentennial of the laboratory, there will be presented a portrait of C. R. Crane, who in very large measure was responsible for the growth of the institution. Mr. Crane was president of the Board of Trustees from 1902 until 1925; he gave a completely equipped laboratory building in 1914, and later, a large sum for an endowment fund. His numerous gifts over a period of more than a generation have been substantial and timely. The Marine Biological Laboratory has received large gifts also from John D. Rockefeller, Jr., the Rockefeller Foundation and the Carnegie Corporation.

From the first, the chief activities of the laboratory have been instruction and research. During the summer, courses are offered in invertebrate zoology; embryology, chiefly of the invertebrates; general physiology; protozoology, and marine algae. The attendance this summer is at a maximum, practically all the space devoted to instruction being occupied. A few changes have occurred in the staff of instructors. In the physiology course, Dr. Carl Schmidt has replaced Dr. Rudolf Höber; Drs. L. G. Barth and Charles Packard have resigned from the embryology staff, their work being taken by Dr. W. W. Ballard, of Dartmouth, and Professor D. M. Whitaker, of Stanford University. In the other courses the teaching staff is the same as last year.

Following a custom initiated by Professor Whitman, and never discontinued, members of the laboratory give weekly lectures in which they discuss their investigations. The first lecture of the current season was given by Professor M. H. Jacobs, the retiring director, who spoke on "Blood and Zoological Classification." Professor S. O. Mast, of the Johns Hopkins; Professor G. H. Parker, of Harvard; Dr. O. E. Schotté, of Amherst, and Dr. Eduard Uhlenhuth, of the University of Maryland, gave the other lectures in July.

Each week there is also a seminar devoted to the presentation of short papers by investigators at work in the laboratory. During July, the topics discussed were some phases of endocrine activity, protozoan studies, aspects of the physiology of muscle and the action of organizers in development. An important feature of these informal gatherings is the lively discussion which follows the presentation of the papers.

The aim of the institution was stated many years ago by Professor Whitman. "The Marine Biological Laboratory attaches itself to no single institution, but holds itself rigidly to the impartial function of serving all on the same terms. . . . The whole policy is national in spirit and scope. The laboratory exists in the interests of biology at large."

SCIENTIFIC NOTES AND NEWS

Dr. Earl Baldwin McKinley, professor of bacteriology, dean of the Medical School and director of medical research at the George Washington University, and Fred Campbell Meier, plant pathologist of the Department of Agriculture, were on the *Hawaii Clipper*, lost over the Pacific on July 28. They were

engaged in research on aerobiology and in making arrangements for the continuation of the collection of micro-organisms, viruses, pollens and dust in the upper air by officers of the trans-Pacific airships.

At the meeting of the Pacific Division of the American Association for the Advancement of Science, held in San Diego during the week of June 20, Dr. S. J. Holmes, professor of zoology of the University of California, was elected president in succession to Dr. J. S. Plaskett, director emeritus of the Dominion Astrophysical Observatory, Victoria, B. C. A full report of the meeting by Dr. J. Murray Luck, secretary of the division, will appear in an early issue of Science.

Wesleyan University at commencement conferred the doctorate of science on Dr. Aaron L. Treadwell, of the class of '88, now professor emeritus of zoology of Vassar College.

The doctorate of science has been conferred by the University of Belfast on Dr. J. P. Hill, professor of embryology of University College, London.

Nature reports that Sir William Bragg, president of the Royal Society and director of the Royal Institution, has been elected a foreign associate of the Paris Academy of Sciences. The number of foreign associates of the Paris Academy is limited to twelve; the only other British foreign associate is Sir Joseph Thomson.

Dr. Wolfgang Ostwald, professor of colloid chemistry at Leipzig, and Dr. Erich Martini, professor of medical zoology at Hamburg, have been nominated as honorary members of the Rumanian Academy of Sciences at Bucharest.

The yearly prize of the International Veterinary Congress at its twelfth annual meeting in New York City was awarded to Dr. George H. Hart, professor of animal husbandry in the College of Agriculture of the University of California, "for the most outstanding work of the year in veterinary science."

At a meeting on July 14 of the Royal College of Surgeons, London, Dr. Hugh Lett was elected president for the ensuing year. At the same meeting the Hallett Prize was awarded to Dr. Howard Hadfield Eddey, of the University of Melbourne.

The American Society for the Study of Allergy has elected the following officers for 1938–1939: *President,* Dr. Harry L. Alexander, St. Louis, Mo.; *President-elect,* Dr. Warren T. Vaughan, Richmond, Va.; *Vice-president,* Dr. Robert L. Benson, Portland, Ore.; *Secretary-Treasurer,* Dr. J. Harvey Black, Dallas, Texas. The 1939 meeting will be held at St. Louis, in conjunction with the meeting of the American Medical Association.

Professor John C. Graham, for twenty-seven years head of the department of poultry husbandry of the Massachusetts State College at Amherst, retired at the close of the academic year.

Dr. Elliott L. McMillen, assistant professor of chemical engineering at the Iowa State College, has resigned to become head of the department of engineering of Lafayette College, and Dr. Grover L. Bridger, of the department of chemical engineering, has been appointed assistant professor of chemical engineering at the Rice Institute.

Dr. Walter W. Wisnicky, for the last eight years director of livestock sanitation with the Wisconsin State Department of Agriculture and Markets, has been appointed professor of veterinary science at the University of Wisconsin. He has obtained leave of absence from his present work and will join the faculty on August 15.

In the department of physics of Indiana University, Dr. F. N. D. Kurie, research associate at the Radiation Laboratory of the University of California, and Dr. E. J. Konopinski, national research fellow at Cornell University, have been appointed assistant professors. Dr. L. M. Langer, of New York University, has been made instructor.

Dr. P. F. English, of the department of forestry and wildlife management, has resigned from the Connecticut State College to accept an assistant professorship of wildlife management at the Pennsylvania State College.

George R. Phillips, from 1926 to 1936 state forester of Oklahoma, has been made acting chief of the Division of State Forests in the U. S. Forest Service.

Dr. R. W. Eschmeyer, for the past eight years associated with the Institute of Fisheries Research at the University of Michigan, has become associate aquatic biologist with the Biological Readjustment Division of the Tennessee Valley Authority, and Earl Cady, of the Cleveland Museum of Natural History, also has joined the division, of which the headquarters are at Norris, Tenn.

Willard W. Hodge, professor of chemical engineering and head of the department of chemical engineering at West Virginia University and director of the Engineering Experiment Station, has been granted a year's leave of absence to conduct work at the Mellon Institute, Pittsburgh, Pa., on the prevention of stream pollution under a fellowship founded by the American Iron and Steel Institute. Dr. A. E. Alexander, ceramic engineer with the Electric Auto-Lite Company of Toledo, has been appointed industrial fellow in mineralogy and petrography.

Dr. C. E. ZoBell, assistant professor of marine microbiology at the Scripps Institution of Oceanography of the University of California, will spend next

year as visiting professor in the department of limnological biology at the University of Wisconsin, where he will hold a research post-doctorate fellowship. He will work in association with Dr. E. B. Fred, Dr. Chancey Juday and other staff members.

Lieutenant Commander Lincoln Ellsworth sailed on July 26 for Southampton on his way to Cape Town, South Africa, for his fourth expedition to the Antarctic. It is expected that the expedition will leave Cape Town on October 1 on the *Wyatt Earp*. Sir Hubert Wilkins will be a member of the party.

At the U. S. Geological Survey, Dr. Philip S. Smith, chief Alaskan geologist, sailed from Seattle, Wash., on June 20, to make the annual investigation of mining conditions and mineral production in Alaska. His first stop is at Juneau, Alaska, where he will join the party under John C. Reed, which is making geologic and topographic surveys on the west coast of Chichagof Island. In connection with the recent allotment of funds to the survey by the Public Works Administration, W. D. Johnston, Jr., left Washington on July 16 for Los Angeles and San Francisco, to organize parties to study manganese, chrome and mercury deposits in California, Oregon and Wyoming.

Members of the department of geology of Northwestern University who are conducting scientific work during the summer include Dr. Edward C. Dapples, who is studying the coal fields of England, France and Germany; Arthur L. Howland and Robert Garrels, who are investigating the iron ores of Newfoundland under the auspices of the Newfoundland Geological Survey; Dr. William E. Powers, who is in Ottawa, Canada, gathering material on the physiographic regions of Canada, and Dr. J. R. Ball, who is continuing his work on the Silurian epoch in Tennessee, Missouri and Arkansas. Dr. John T. Stark made studies in July of the Val d'Or gold field in Canada, and this month will conduct a field course in the Ontario-Minnesota boundary region.

Dr. Thomas J. LeBlanc, professor of preventive medicine at the University of Cincinnati, and five students are attending the regular summer course of four weeks at the School of Tropical Medicine, Puerto Rico. Dr. Howard B. Shookhoff, who holds a fellowship from the New York Academy of Medicine, plans to spend five months at the school.

Dr. Samuel H. Williams, professor of biology at the University of Pittsburgh, has left for Port-au-Prince, Haiti, where he will study for about two months the archaic insect fauna in the interior.

Dr. Stig Ryden, of the Göteborg Museum, Sweden, is making a tour of the principal museums and ethnographical collections in the United States, following which he will go to Bolivia, where he plans to undertake ethnographical work.

The fiftieth anniversary of the founding of the Storrs Agricultural Experiment Station at the Connecticut State College was celebrated on July 28. The following program, presided over by President Albert N. Jorgensen, was presented: "Milestones and Monuments—A Historical Sketch of the Station," by Director William L. Slate; "The Place of an Agricultural Experiment Station in the Economy of a Commonwealth," by Dr. R. E. Buchanan, director of the Iowa Agricultural Experiment Station; "Dreams, Goals, Deeds," by Dr. J. L. Hills, dean of the college of agriculture and director of the experiment station of the University of Vermont.

The autumn sessions of the National Academy of Sciences will be held at the University of North Carolina on October 24, 25 and 26.

The sixtieth meeting of the American Astronomical Society will be held from September 14 to 16 at the University of Michigan, under the presidency of Dr. Robert G. Aitken, director emeritus of the Lick Observatory.

The eighteenth annual meeting of the Highway Research Board will be held in the building of the National Academy of Sciences and National Research Council, Washington, D. C., from November 30 to December 2.

The U. S. Bureau of Fisheries has established an office at the Utah State Agricultural College, Logan, for the purpose of cooperating with the Forest Service in developing a stocking program for the lakes and streams of Forest Region No. 4. Dr. Stillman Wright is in charge of the office.

The sum of approximately $37,000 to be spent over a period of five years has been given by the Commonwealth Fund, New York, to the University of Minnesota to be used for graduate medical education. The fund will provide for a series of advanced courses in at least five branches of medicine.

The London *Times* states that an expedition, organized at the Scott Polar Research Institute, is visiting West Spitsbergen this summer. The object of the expedition is twofold. The nature and processes of glacial erosion will be investigated in conditions resembling those which prevailed in Great Britain during the Ice Age, and were responsible for many of the features to be found in the mountainous regions of these islands. Secondly, the raised beaches and river terraces will be examined and an attempt made to correlate them with those of northwest Europe. Members of the party are: L. H. McCabe, leader and geomorphologist; M. B. Adams, R.E., surveyor; W. G. V. Balchin, geomorphologist; W. B. Harland, geologist; P. M. M. Pritchard, in charge of medical stores; N. Pye, surveyor.

DISCUSSION

ONE-MAN CITATION OF AUTHORITIES FOR BOTANICAL NAMES

BOTANISTS should consider the advantages of the one-man citation of authorities for scientific names. As matters now stand it is difficult, when writing of plants, to do so without constantly turning to manuals for a verification of every one of those complex citations such as: *Luzula campestris* (Linnaeus) De Candolle, var. *multiflora* (Ehrhart) Čelak; or *Croton texensis* (Klotzsch) Mueller of Argau; or *Lappula Redowskii* (Hornemann) Greene, var. *occidentalis* (Watson) Rydberg. But it is a simple affair to recall *Quercus phellos* Linnaeus, *Quercus macrocarpa* Michaux, *Carpinus caroliniana* Walter, *Salix humilis* Marshall.

The zoologists have long reduced the authority citation to one man. Alas, it seems to me they have chosen in every case the wrong man! They have picked out *the original authority, who first described the species,* on the basis that he deserves the credit. But take the green heron, often given as *Butorides virescens* (Linnaeus). Suppose that we wish to return to the original description of this bird. Will we in all Linnaeus' writings find a creature under the name *Butorides virescens*? We will not, for the simple reason that Linnaeus never made such a combination. The green heron is almost hopelessly buried from us in his voluminous writings under the name *Ardea virescens,* while the author of the combination *Butorides virescens* is Bonaparte, and if zoologists would cite it that way we would have some idea how to trace our way back to an original description. Bonaparte will, almost of necessity, tell us whence he derived the name *virescens* that he has transferred to a new genus.

The botanical one-man citation, as it was formerly much used in this country and abroad, was the opposite of the zoologists' present system. It cites the man who transferred the specific name into the *correct* genus. Thus the pawpaw, now given as *Asimina triloba* (Linnaeus) Dunal, would be, under the one-man citation, simply *Asimina triloba* Dunal. This sort of citation would, in the aggregate, save hours of time for everyone who uses botanical nomenclature.

The objections to this type of citation are these:

(1) "The original author is deprived of credit." But the purpose of citing authorities is simply bibliographical. It is to distinguish John Doe's homonym from Richard Roe's. And to lead you back, *via* his name, to a printed description. The lure of giving credit is pernicious, encouraging the making of ill-founded species.

(2) "The one-man citation might encourage name-jugglers to attach their names to everything." But this is done with equal success under the two-man system. Look at the sport that Otto Kuntze and Dr. E. L. Greene had in transferring everybody's species into a very new, or a very old genus, and thus forcing you to mention them endlessly.

(3) One-man citations "conceal the history of the species." Why, except in elaborate taxonomic work, should it be revealed? Even then the one-man citation would still be enough for the titular name of the plant. The name-bringing synonym could be cited, along with all other synonyms, under the accepted name.

The double citation, in America, is a thing chiefly of the last forty years. In England and France it is still highly unpopular and often disregarded. The one-man citation was, in effect, used by De Candolle, Lamarck, the Hookers and Asa Gray, to mention but a few of the most famous names. The double citation is shallowly rooted in custom and could still be easily weeded up.

DONALD CULROSS PEATTIE

TREATMENT OF BLACKTONGUE WITH COZYMASE

THE report of Elvehjem, Madden, Strong and Woolley[1] that nicotinic acid will cure blacktongue of dogs has created considerable interest in the role of nicotinic acid in metabolism. Since codehydrogenase (cozymase) contains nicotinic acid, it seemed desirable to determine whether this substance, given in doses below the effective level of nicotinic acid, would have a curative effect on blacktongue.

Professor O. Warburg very kindly furnished us with 5 mg of diphosphopyridine nucleotide and 5 mg of triphosphopyridine nucleotide. Three milligrams of each preparation were given intramuscularly to a dog in an acute attack of blacktongue. No therapeutic effect was seen.

We then prepared approximately 200 mg of partially purified cozymase (diphosphopyridine nucleotide) according to the method of Meyerhof and Ohlmeyer.[2] A similar preparation is reported by them to be approximately 80 per cent. pure. The activity of our preparation and that of Warburg's triphosphopyridine nucleotide was determined by the growth-stimulating effect on *Haemophilus parainfluenzae,* according to the method of Lwoff and Lwoff.[3]

The order of activity of our preparation approximated that of Professor Warburg's material (in dilution of $1:2\times10^8$ in our hands).

Two dogs in an acute attack of blacktongue were

[1] C. A. Elvehjem, R. J. Madden, F. M. Strong and D. W. Woolley, *Jour. Amer. Chem. Soc.*, 59: 1767, 1937.

[2] O. Meyerhof and P. Ohlmeyer, *Biochem. Zeits.*, 290: 334, 1937.

[3] Andre Lwoff and Marguerite Lwoff, *Proc. Roy. Soc.* B. 122: 352, 1937.

each given a total of 50 mg of this material intravenously without any observable therapeutic effect.

Conclusion

No therapeutic effect on blacktongue was observed from the intravenous administration of 50 mg of an impure preparation of diphosphopyridine nucleotide.

Floyd S. Daft
H. F. Fraser
W. H. Sebrell
Margaret Pittman
National Institute of Health,
U. S. Public Health Service

THE NATURE OF THE MUCO-POLYSACCHARIDE OF SYNOVIAL FLUID[1]

The viscous fluid bathing the joint surfaces and thought to be produced by cells of the synovial epithelium yields on acidification a stringy precipitate which has been called the synovial mucin. By a modification of the methods described for the isolation of chondroitinsulfuric acid from cartilage[2] we have succeeded in obtaining from bovine synovial fluid a sulfur- and phosphorus-free polysaccharide acid of high molecular weight, containing per equivalent weight one equivalent each of nitrogen, hexosamine, acetyl and hexuronic acid. It appears to be identical with hyaluronic acid, the polysaccharide isolated from bovine vitreous humor,[3] from human umbilical cord[4] and from hemolytic streptococcus.[5] This conclusion is based on the similar composition and rotation and on the hydrolysis at a similar rate by the "autolytic enzyme" of pneumococcus.[6] We have obtained about 200 to 250 mg of the acid per liter of cattle synovial fluid, and 225 mg per liter from 160 cc of a human knee exudate. Like other acid polysaccharides the carbohydrate in synovial fluid occurs as a salt and not bound to protein. Solutions of the isolated polysaccharide are extremely viscous and the substance apparently is responsible for most of the viscosity of the native fluid even though present in a low concentration. It is of interest that the same polysaccharide is elaborated by hemolytic streptococci (Group A, Lancefield), by the ciliary epithelium and by the synovial tissue. It may be of further interest that hemolytic streptococcal infection is frequently incriminated in inflammatory conditions affecting those tissues in which the polysaccharide is found.

Karl Meyer
Elizabeth M. Smyth
Martin H. Dawson

THE LAND-SNAIL AN INTERMEDIATE HOST OF THE CECAE FLUKE OF POULTRY

The life history of *Postharmostomum gallinum* has heretofore been unreported. Experiments conducted during the past year have revealed that land snails, *Eulota similaris,* are the common carriers of this fluke under natural conditions. Snails collected in fluke-endemic poultry farms near Honolulu have been found heavily infected with larval flukes (adolescercariae); the largest of these flukes measured 0.87 mm long and 0.39 mm wide, and possessed well-developed suckers and ceca closely resembling those of the adult fluke. When three two-month-old laboratory-raised cockerels were fed such infected snails and killed one month later, adult *P. gallinum* flukes 5 to 6 mm long by 2 mm wide were recovered from the ceca. Control birds under the same laboratory conditions, but not fed infected snails remained free from all helminths. The results reported here are of importance from the control standpoint, in view of the common occurrence of these flukes in poultry in Hawaii.

Joseph E. Alicata
Department of Parasitology,
University of Hawaii

SCIENTIFIC BOOKS

LOW TEMPERATURE PHYSICS

Low Temperature Physics. By M. and B. Ruhemann. Cambridge: at the University Press; New York: The Macmillan Company, 1937. ix + 313 pp. Price, $5.00.

Kammerlingh Onnes, the acknowledged father of low temperature research, frequently compared his investigations to a polar expedition. Lengthy and careful preparation was a preliminary. The actual work had to be carried on by a large group highly organized, a squad of technicians to operate the hydrogen liquefier, another for the helium liquefier, a group of observers at galvanometers, others at manometers and so on. Then, when the low temperature region was entered, it was a kind of "never-never" land in which the ordinary rules of behavior were suspended. Electrical and thermal conductivity took on outlandish values, radiation disappeared, and vapor pressures vanished.

It is this character found in all low-temperature

[1] From the Department of Ophthalmology of the College of Physicians and Surgeons, Columbia University, and the Institute of Ophthalmology of the Presbyterian Hospital, and from the Edward Daniels Faulkner Arthritis Clinic of the Presbyterian Hospital, New York.

[2] K. Meyer and E. M. Smyth, *Jour. Biol. Chem.*, 119: 507, 1937.

[3] Recently the identical polysaccharide has also been isolated from pig vitreous humor.

[4] K. Meyer and J. W. Palmer, *Jour. Biol. Chem.*, 114: 689, 1936.

[5] F. E. Kendall, M. Heidelberger and M. H. Dawson, *Jour. Biol. Chem.*, 118: 61, 1937.

[6] K. Meyer, R. Dubos and E. M. Smyth, *Jour. Biol. Chem.*, 118: 71, 1937.

research which gives the field a kind of unity and which fully justifies this interesting monograph by one of the leading "explorers" of our day. Because of the variety of observations which are now carried on below one hundred degrees absolute it has been impossible in a small book to do more than pick out and describe briefly a few of the more striking examples in each line of work. As stated in the preface: "Though this book may be of some use to the specialist, we have had in mind as prospective readers rather physicists specializing in other fields . . ." For this purpose the material is admirably selected.

The book is divided into four parts, the first and longest being entitled "Phase Equilibrium" and dealing with the history and recent developments in liquefaction, measurements of low temperatures and phase diagram studies. The early work of Pictet, Dewar and Linde is graphically described with many quotations from original letters and papers. Unfortunately, the date of Kammerlingh Onnes' death is given as 1924 instead of 1926. The second part deals with the "Solid State," x-ray methods, thermal energy, the "Third Law of Thermodynamics." The third part covers "Orbit and Spin," the production of temperatures of the order of one hundredth of a degree by the Giauque method. The fourth part, "The 'Free' Electron," deals with superconductivity. There is an excellent bibliography covering the literature up to May, 1937.

The work described undoubtedly constitutes one of the most exciting chapters in modern science and the authors have presented the material in a vigorous and interesting manner. As a reference book, it could have been made much more valuable by the more careful labelling of equations and figures with units.

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SOUND WAVES, THEIR SHAPE AND SPEED

Sound Waves, Their Shape and Speed. By DAYTON C. MILLER. The Macmillan Company. 1937.

PROFESSOR MILLER in this small book gives us an account of certain work which he has done some time ago and never before fully reported. The first research here treated included the development of his phonodeik, the instrument with which he obtained by purely mechanical means most satisfactory photographic records of the form of sound waves. The second major item deals with a series of experiments in which apparatus somewhat like the phonodeik was used to measure the velocity of sound from high-power guns, the form of their sound-waves, and the pressures produced by them at various distances. In addition, there is an important chapter on spark-photography of sound waves, and of bullets in flight, and one on the velocity of sound in air.

The account which Professor Miller gives of these studies is a model of clarity, and the research itself is a model of thoroughness and scientific accuracy. Every student of physics should read this book for the interest in the subject-matter and for the example it sets in proper research methods and in the presentation of results.

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SPECIAL ARTICLES

EXPERIMENTAL INTERSEXUALITY: THE PRODUCTION OF FEMINIZED MALE RATS BY ANTENATAL TREATMENT WITH ESTROGENS[1]

THE production of masculinized female rats by antenatal administration of androgens has been reported.[2,3,4] Until very recently attempts to produce feminized male rats by the antenatal administration of estrogenic substances (estrone, estradiol and estradiol benzoate) have been unsuccessful. Dosages that would conceivably cause feminization of the genetic male fetuses, when administered to pregnant rats, caused resorptions of the pregnancies. However, one full-term litter which showed slight changes in sexual development was obtained. The mother of this litter had been given 0.8 mg estradiol in divided doses from the thirteenth day to the twentieth day of pregnancy. Two new-born males of this litter were serially sectioned, and it was noted that there had been definite inhibition of development of the prostatic diverticula and of the seminal vesicles.

A generous amount of estradiol dipropionate has been made available to us through the courtesy of Dr. Ernst Oppenheimer, of Ciba Pharmaceutical Products, Inc. This compound is very slowly absorbed and consequently has a very prolonged estrogenic effect. Thirty-two pregnant rats have been injected with this compound, usually in single doses of 0.375 mg to 4.0 mg on the thirteenth, fourteenth or fifteenth day of pregnancy. Nineteen of these animals have carried to term and 24 males have been obtained from these litters. Fourteen of these males, the mothers of which had received 2.0 to 4.0 mg of estradiol dipropionate, had grossly visible nipples at birth and were hypospadiac. Normally nipples are not present in the males rats of our colony. Normal new-born males

[1] This work has been supported in part by a grant from the Josiah Macy, Jr., Foundation.

[2] R. R. Greene and A. C. Ivy, SCIENCE, 86: 200, 1937.

[3] R. R. Greene, M. W. Burrill and A. C. Ivy, *Proc. Soc. Exp. Biol. and Med.*, 38: 1, 1938.

[4] R. R. Greene, M. W. Burrill and A. C. Ivy, SCIENCE, 87: 396, 1938.

have a completely formed penile urethra. In eight animals (all from different litters) the testes were in abnormally high position and in three, the testes were in the typically female position, at the base of the kidney.

Eight of these new-born males (each from a different litter) have been serially sectioned to date. One animal (0.5 mg estradiol dipropionate) showed marked inhibition of the ventral prostatic diverticula and a moderate inhibition of the posterior diverticula. In another animal (1.0 mg estradiol dipropionate) the ventral prostatic diverticula were absent and the posterior diverticula were scanty. In six animals (2.0 to 4.0 mg estradiol dipropionate) the prostatic diverticula were entirely absent. Furthermore, in each of these six animals there was a vagina which was comparable in development to that found in the normal new-born female. In four of these six cases marked inhibition of the right vas deferens was found. The lumen of the vas was absent throughout most of its length and, in some regions, even the epithelial cells had apparently completely degenerated. In all animals the seminal vesicles exhibited some inhibition or departure from normal development in that the cranial flexure which is typical of this organ at this stage was absent. The epididymides also showed evidence of inhibition inasmuch as the convolutions of the ducts were less numerous than in the normal males.

On the basis of the few animals observed, it seems that the amount of development of female structures (vagina and nipples) and inhibition of male structures has a fairly definite relationship to the dosage given.

The females in these litters have not been examined microscopically to date. However, some changes from the normal have been grossly visible. Large nipples have been present in the new born. Normally nipples do not appear in the female rats of our colony until the fifth to tenth day. Usually in the same litter the females had more and better developed nipples than the males. The uteri were grossly enlarged and apparently distended. The development of the ovarian capsule had been inhibited; with the higher dosages no ovarian capsule was present.

CONCLUSIONS

The administration of large amounts of an estrogenic substance to the pregnant rat has so modified sexual development of genetic male fetuses that feminized males or intersexed animals have resulted.

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XANTHINE OXIDASE: AN ALLOXAZINE PROTEID

A XANTHINE oxidase preparation has been obtained that is 500 times more active per unit dry weight than the whole milk used as a source. The activity has been determined by measuring manometrically the oxygen consumption, usually with hypoxanthine as the substrate, though xanthine and aldehydes may also be employed. Solutions of this enzyme preparation containing 6 mg/cc have a strong golden brown color and possess an absorption spectrum with a band in the visible lying between λ400–500 mμ. This band disappears if hypoxanthine is added to a solution from which air is excluded. The original color can then be rapidly restored by the admission of air. If the spectrum of the reduced enzyme preparation is subtracted from that of the oxidized form, a spectrum is obtained which is similar to that of the "gelbe ferment" in having two bands centered at λ370 mμ and λ465 mμ, respectively. The prosthetic group may be split off from the protein by the addition of acid or alcohol. Such solutions are pure yellow in color, fluoresce strongly and possess the characteristic absorption spectrum of a flavin with two bands centered at λ450 mμ and λ375 mμ. Definite proof of the flavin nature of the prosthetic group is furnished by the fact that it can be quantitatively converted by the method of Warburg and Christian[1] into a lumiflavin, the absorption spectrum of which is identical with that given by these workers. Complete separation of the flavin part from the protein without destruction of the latter has not yet been accomplished. It is, however, possible to obtain a partial separation. The protein part so obtained shows a 3–4 fold increase in activity on the addition of the flavin component. The flavin alone is inactive. If the flavin containing co-ferment of the amino acid oxidase recently isolated by Warburg and Christian[2] or lactoflavin phosphate is substituted no increase in activity is obtained. It therefore appears that xanthine oxidase is to be classified as an alloxazine proteid whose active group is of a different composition from those flavins hitherto known. Further details will be published elsewhere.

I am indebted to Professor Otto Warburg for his valuable advice and generous provision of laboratory facilities during this investigation.

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[1] O. Warburg and W. Christian, *Biochem. Zeits.*, 266: 377, 1933.

[2] O. Warburg and W. Christian, *Biochem. Zeits.*, 296: 294, 1938.

COLLETOTRICHUM CIRCINANS AS A SEMI-QUANTITATIVE TEST UNIT FOR THE GROWTH SUBSTANCE PRODUCED BY RHIZOPUS SUINUS

WHILE testing the filtrate of *Rhizopus suinus* Nielson on the growth of various species of fungi, it was noted that *Colletotrichum circinans* (Berk.) Vogl. gave consistent increments in yield over a limited range of concentrations. This characteristic response of the organism mentioned suggested its use as a means of measuring the relative growth substance concentration. Subsequent work has shown that this fungus will serve not only as a qualitative but also as a semi-quantitative test unit for the growth accelerator concerned. Nielson and Hartelius (1932) showed that the extract from *Rhizopus* exerted an influence on the dry weight yield of *Aspergillus niger* Van Tiegh., but gave negative results when tested with the oat coleoptile. Although its chemical structure is still unknown, it has properties which render it insoluble in common organic solvents, and it is stable to both oxidation and heat. Their results, which were duplicated in this laboratory, prove that it is not a nutrient and that it is not identical with heteroauxin.

In order to measure this substance, investigators have relied, heretofore, upon *Aspergillus niger*. The *Aspergillus* technique does present certain distinctive features, *viz.,* (1) the time involved is short and a large number of runs can be completed in a given time; (2) the effect is an initial one, and (3) the comparisons are based on dry weight yields, and thus an unevenness of growth does not invalidate the results. The *Colletotrichum* technique, on the other hand, has several definite advantages, *viz.,* (1) the change in yield is greater per increment of growth substance added; (2) the results of replicates show a lesser variation; (3) temperature fluctuations over a few degrees (standard 25° C.) are of little significance; and (4) successive daily changes in the growth rate for a given culture can be recorded and studied.

The method is essentially as follows: The *Rhizopus* mat is filtered from its liquid substrate and the resultant filtrate is concentrated, by partial evaporation, to one third or less of the original volume. This constitutes the stock solution. A 1 cc aliquot of the stock solution or a dilution thereof is placed in the bottom of a sterile 100 mm petri dish. To this is added 30 cc of a nutrient-agar solution containing M/400 $MgSO_4$, M/220 KH_2PO_4, M/16 NH_4NO_3, M/5.5 sucrose, 1.7 per cent. agar and a trace of ammonium tartrate.

Plates made in this manner are cooled and are inoculated with circular blocks (1 mm diam.) of non-fruiting hyphae of *Colletotrichum circinans* growing on an agar substrate. Diameter measurements are made every few days with the aid of a mimeoscope. These figures are compared directly or comparisons are made of the slopes of the plotted curves. Diameter comparisons, and not area measurements, are used since they more nearly approach the true values. This point will be presented in a subsequent paper.

The example below, which has been repeated several times, will serve to illustrate this technique. The actual diameters are measured every two or three days. The values for the third day are used as the starting point, since the transfer of the inoculum affects the initial growth, in an unpredictable manner, invalidating the use of the size of the planting as the criterion. Values for subsequent days are measured as increases over the values for the third day. These last are then corrected so that each test will have the same base line as the control.

These corrected diameters (in mm's) become:

	Days					
	3	5	7	9	12	15
Control	0	7.2	11.0	14.8	19.0	23.0
plus 1 cc	0	9.8	17.2	21.8	28.2	32.2
" 2 cc	0	11.2	18.2	24.2	32.8	38.6
" 3 cc* ...	0	10.4	18.6	26.0	35.4	44.4

* The value 3 cc refers to 1 cc of a stock solution three times as concentrated as the original filtrate.

The values for the fifteen-day period are most profitably used. When an unknown is run, it is necessary to interpolate for those which fall intermediate to the values listed above. This method, therefore, becomes of special interest for small changes in the amount of growth substance and can be used also for larger changes by concentrating or diluting the stock solution so that the test values will fall within this range.

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BOOKS RECEIVED

CATTELL, RAYMOND B. *Crooked Personalities in Childhood and After.* Pp. xi + 215. Appleton-Century. $2.00.

International Encyclopedia of Unified Science: Vol. I, No. 1, Encyclopedia and Unified Science, OTTO NEURATH and others. Pp. viii + 75. *No. 2, Foundations of the Theory of Signs,* CHARLES W. MORRIS. Pp. vii + 59. University of Chicago Press. $1.00 each.

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Recueil des Travaux Chimiques des Pays-Bas, Tome 57, No. 6, June, 1938. LIVRE JUBILAIRE J. BÖESEKEN. Pp. 344. Illustrated. D. B. Centen's Uitgevers-Maatsch, Amsterdam. Dutch florins 3.

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WILLIAMS, ROGER J. *A Textbook of Biochemistry.* Pp. x + 525. 17 figures. Van Nostrand. $6.00.